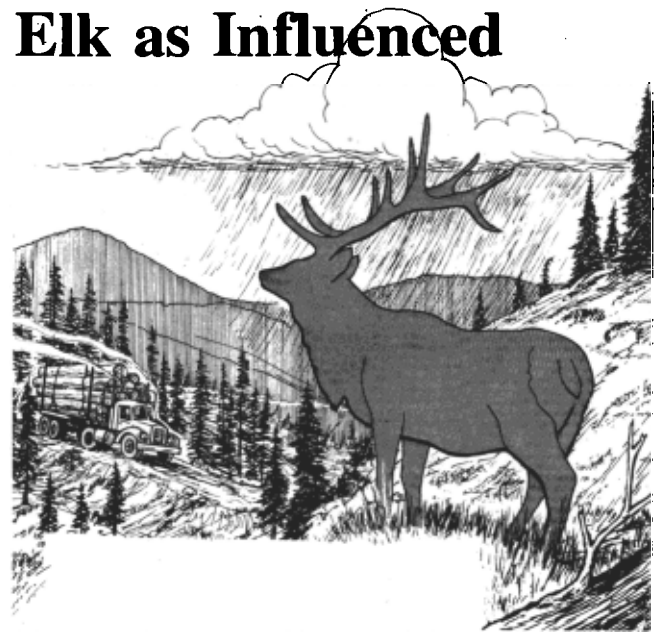
Habitat Effectiveness for Elk as Influenced By Roads and Cover



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ABSTRACT—Pellet counts conducted over an eight-year period confirmed that elk in western Montana tend to avoid habitat adjacent to open forest roads. The area avoided increases where the density of tree cover is low. Forest roads open to traffic cause available habitat to be less than fully effective. A method for determining the losses of effective habitat is presented.

Declines in elk use of habitat adjacent to forest roads have been documented in several studies (Rost and Bailey 1974, Ellison 1974, Ward 1976, Perry and Overly 1976, Burbridge and Neff 1976, Marcum 1976). The area of avoidance has been reported as one-fourth to one-half mile from the road, depending on the amount of traffic, road quality, and density of cover near the road. Within this zone, available habitat is only partially used, and is thus less effective than it would have been in the absence of the road.

In this paper, I have utilized data from an eight-year study of elk pellet distributions in western Montana to develop (1) a model of habitat effectiveness in relation to roads and cover density, and (2) a method for estimating habitat effectiveness under various levels of road density and cover.

Methods

During late August and early September of 1970 through 1977, pellet-group counts were conducted on 80 square miles of forested elk range in western Montana. Pellet groups were counted in continuous belt transects 4 feet wide located along the contour every 500 vertical feet from 3,500 to 6,500 feet of elevation. An average of 340 miles of transects was searched, and 7 to 10 thousand elk pellet groups were recorded each year. All groups were classified as fresh, new, old, or very old on the basis of softness, color, and weathering; and the location of each group was recorded.

Field observers classified tree canopy cover along transects into four categories: no trees, canopy under 25 percent, 25 to 75 percent, and more than 75 percent. In addition, the distance from each transect segment to the nearest open road was determined annually. As defined in this study, an open road was one accessible for motor vehicle traffic. Roads on the study area are mostly single-lane with unimproved surfaces, and distances to open roads were modified annually by construction and closures.

Pellet groups classified as very old were deleted from analysis on the assumption that they represented carry-over from previous years as well as elk use during the winter when many roads are not open. All other pellet groups were summarized for each year by cover category and distance from a road. Within each cover category the average number of pellet groups per acre was calculated in tenth-mile increments to a distance of 2 miles. Annual summaries were then averaged to produce four data sets that combined all observations for eight years.

Analyses

Graphs of the four data sets (light dashed lines in *figure 1*) demonstrate the expected increases in elk use with increasing distance from roads. The distance at which no further increase occurred was substantially reduced by the presence of cover. In the absence of trees, elk use was still increasing between 1.5 and 2.0 miles away from roads. With any crown canopy of less than 75 percent, use was virtually stabilized beyond 0.9 mile, and under very dense canopy there was no consistent increase in use beyond 0.6 mile.

In *figure 1*, the potential level of elk use (heavy dashed line) has been taken as the average beyond the point at which no consistent increase occurred; and the curves predicting the depression in use near roads (solid lines) have been described with algebraic transforms of the class X^n (Jensen and Homeyer 1971). These four curves provide a model for predicting the level of habitat use by elk at various distances from forest roads.

In an area with very dense tree canopy, for example, the proportionate elk use within 0.1 mile of a road is predicted to be 37 percent of the potential occurring beyond the influence of the road: midpoint for 0.1 mile distance, D = 0.05; endpoint for the influence of the road = 0.6; exponent for the transformed curve, n = 0.4; and $(0.05/0.6)^{0.4} = 0.370$.

Where potential use is represented by 41.4 pellet groups per acre, as it was in this study, the presence of the road will reduce elk use to 15.3 pellet groups per acre. Concurrently, elk use of the area between 0.1 and 0.2 mile will be reduced to 57.4 percent of poten-

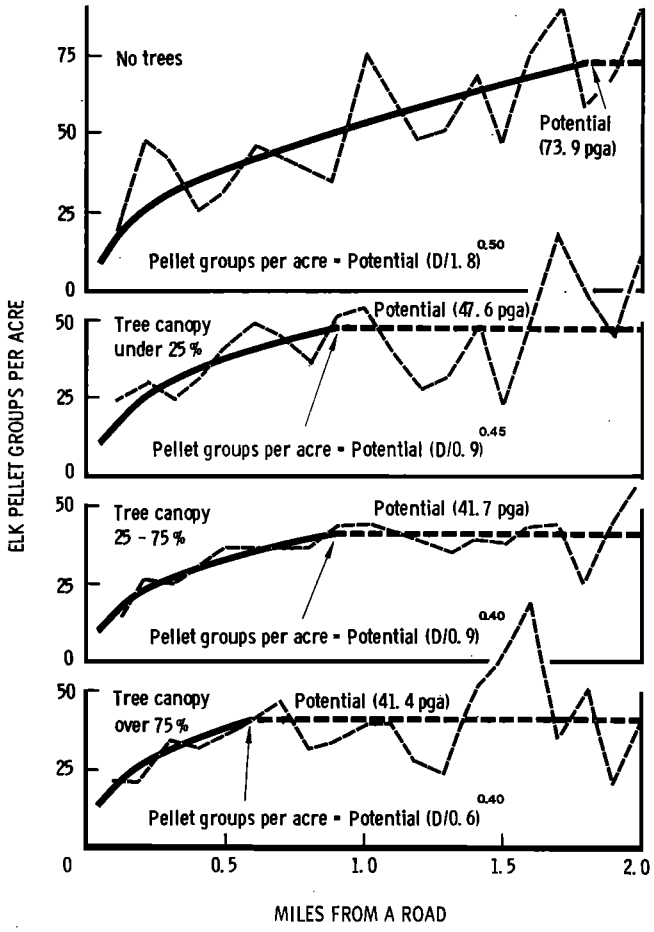

Figure 1. Elk pellet densities at increasing distance from open roads under four categories of tree cover. Plotted averages superimposed.

tial, and reduced use is likely at all distances under 0.6 mile.

The reliability of these estimates is limited by the fact that the curve forms were developed directly from the data. However, the derived forms do satisfy the analytic requirement of agreement with expected trends; and some indication of the strengths of the relationships is provided by fitting the models back on the data from which they were derived. Not unexpectedly, the poorest fit occurs where no tree cover is available ($r^2 = 0.55$) and other factors, such as topography, may influence elk use. As tree canopy increases, variance associated with factors other than cover is reduced and the least squares fit for the three curves with trees present is considerably improved: $r^2 = 0.66$, 0.93, and 0.87, respectively, for <25, 25-75, and >75 percent canopy coverage.

Application of the Model

The utility of the data in *figure 1* is somewhat limited because the model does not deal with the combined influences of several roads or provide a quantified estimate of habitat loss. But if it is assumed that all effects are additive, it is possible to derive a presentation that will satisfy this need.

Consider, first, the influence of a single forest road in an area of 25 to 75 percent canopy cover. For each linear mile of road, there are 64 acres on each side and within 0.1 mile that are only 31.5 percent effective (for tree canopy 25-75 percent: $(0.05/0.9)^{0.4} = 0.315$). The 128 acres adjacent to the road, then, are equivalent to 40.3 fully effective acres and the loss of habitat is equivalent to 87.7 acres. Between 0.1 and 0.2 mile from the road, another 128 acres are 48.8 percent effective; and between 0.2 and 0.3 mile there are 76.7 effective acres. Similar calculations to a distance 0.9 mile from the road predict a loss of 326.2 acres of effective habitat over an area 1.8 miles wide.

Now consider a situation in which several roads are evaluated simultaneously. With a road density of 1 mile per section (square mile) some habitat between roads will be affected from both directions. In the example above, the net loss out to 0.5 mile from the road was 275.8 acres of effective habitat, with an additional loss of 25.2 acres in each of two adjacent sections. Where these adjacent sections also have a mile of road, the total loss is 326.2 acres per square mile and the available elk habitat is equivalent to 313.8 effective acres per section.

Comparable calculations for road densities up to 3 miles per square mile and four densities of tree canopy are summarized in *figure 2*, and associated regression coefficients are presented in *table 1*. The importance of cover in maintaining effective habitat for elk is particularly apparent in *figure 2*. In an open environment, with no tree cover, less than 1 mile of road per square mile will eliminate effective habitat; and even very dense cover cannot be considered effective when road densities approach 3 miles per section.

Table 1. Coefficients for predicting loss of effective elk habitat.[1]

Tree canopy cover	Acres per mile per section
No trees	766.3
<25%	354.9
25-75%	326.2
>75%	216.0

[1] *With a road density of 0.5 mile per section and tree cover under 25 percent, habitat loss is 177.5 acres per section (0.5 × 354.9 = 177.5).*

Evaluation of Habitat

The concept of effective habitat should not be misused by applying these coefficients to unsuitably small

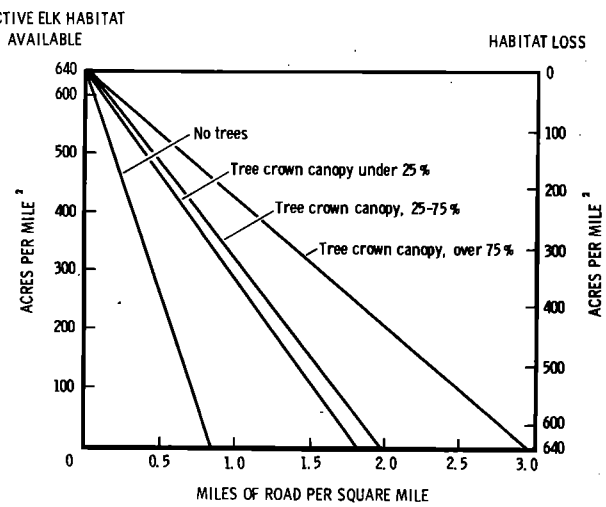

Figure 2. Predicted levels of effective elk habitat with different road densities and tree cover.

units of elk range. Neither elk nor the influences of roads can be confined to small areas, and it is clearly not valid to predict the probable influence of road construction or road closure on units smaller than the area readily available to animals. An absolute minimum area of evaluation should probably be 2,000 acres.

Because areas this size normally include a mosaic of different tree densities and openings, it may be necessary to estimate habitat effectiveness on the proportionate areas of various cover types. As an example, visualize a 3,200-acre forested drainage in which there are 3 miles of road and four 40-acre clearcuts. Further assume that the drainage averages 25 to 75 percent tree canopy cover except for 480 acres with canopy under 25 percent and another 480 acres with canopy over 75 percent.

The average road density in the 5 sections is 0.6 mile per section, and the habitat available to elk consists of 0.25 square mile of openings and 0.75, 3.25, and 0.75 square miles of the three tree-density categories. The sum of the products of road density, area in square miles, and appropriate prediction coefficients (*table 2*) predicts a decline of habitat effectiveness equivalent to 1,008 acres.

Table 2. Hypothetical evaluation[1] of elk habitat effectiveness in a 3,200-acre drainage with 3 miles of road and several tree-cover types.

Acres of cover types	Area	Prediction coefficient	Reduction in effective habitat
	Square miles		*Acres*
160 of clearcuts	0.25	766.3	114.9
480 <25% cover	.75	354.9	159.7
2,080 25-75% cover	3.25	326.2	636.1
480 >75% cover	.75	216.0	97.2

[1]*Road density = 0.6 mi/mi². Density × miles² × coefficient = habitat loss (acres).*

A final consideration involves the influence of road closures in recovering estimated losses of effective habitat. In the example just presented, the area of evaluation was judged to be 68 percent effective with the road open. Presumably, closure of the road will lead to eventual full use by elk. It should be noted, however, that "effective habitat" is a relative term. The actual quality of habitat and productive potential can vary considerably from area to area and may be substantially modified by activities other than road management.

Negative values.—In some initial tests of this model, it became clear that it is entirely possible to obtain negative values for habitat effectiveness where road densities are high and recent timber harvest has been extensive. Test areas producing negative values were only lightly used by elk; but it is recognized that habitat effectiveness in occupied elk range probably cannot be reduced below 10 to 15 percent by roads alone. At very low levels of habitat effectiveness, such factors as topography, cover patches, and behavior patterns of elk will override the influence of open forest roads and traffic.

Other Considerations

Road management is a powerful means of manipulating habitat for elk, but roads should not be considered independent of other criteria by which elk habitat is evaluated. The derivations in this paper are contingent on the assumptions that existing habitat contains a satisfactory array of cover and foraging areas and otherwise provides for the requirements of elk.

Published recommendations for coordinating forest management with elk management (Lyon 1975, Black et al. 1976, Thomas et al. 1976, and others) provide information intended to aid the manager in planning. All available information should be used in every decision. ■

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